

**Notes on Michigan Pteridophytes, II.  
Distribution of the Ophioglossaceae**

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In the years since the publication of *Ferns of Michigan* (Billington, 1952) no part of the fern flora of the state has been the subject of as much intensive study as the genus *Botrychium*, the Moonworts and Grape Ferns. The fact that all of the Michigan species, even the supposedly rare Moonworts, are locally abundant in suitable habitats has made possible field observation of variation within large populations. The occurrence of many mixed populations, with from two to five species existing together, has permitted the testing of species criteria on living or freshly collected plants from identical habitats rather than on pressed, dried material, a great advantage in a group such as this where the differences between taxa are rather subtle and are frequently lost or obscured in pressing.

As the result of these studies two taxa previously regarded as forms by many botanists have been shown to deserve species status, *Botrychium minganense* Victorin and *B. oneidense* (Gilbert) House, while a third which had been overlooked in recent treatments of American ferns is now recognized as occurring here, *B. ternatum* (Thunb.) Swartz. At the same time it has become apparent that some so-called varieties and forms are responses to environment while others appear to be merely the youngest or oldest plants in the population. The taxonomic and cytological phases of these studies, largely the work of Dr. Warren H. Wagner, Jr., of the University of Michigan, have been reported in detail in this Journal and elsewhere (Wagner, 1955, 1959, 1960a, 1960b, 1961a, 1961b, 1961c, 1961d, 1962, 1963a, 1963b; and Wagner and Lord, 1956).

I have had the pleasure of joining Dr. Wagner on many of the Michigan field trips during his *Botrychium* studies. In addition, my wife and I have made special efforts to find and collect grape ferns during nearly twenty years of fern hunting. The fact that our field books show nearly 70 localities in 39 of Mich-

igan's 83 counties for one species, *Botrychium matricariifolium* A. Braun, may serve as an indication of our success. The actual discovery of many of these plants was made by Mrs. Hagenah, and on numerous occasions I have returned from an excursion up a *Woodsia* cliff or into a *Dryopteris* swamp to find some area near the road hung with markers indicating the locations of one or more species of grape ferns.

In view of the taxonomic realignments within the group and the large number of new records available it seems desirable to present a completely new set of distribution maps plus some observations on variation within the species and on the ecology and local distribution of each species. I am grateful to Dr. Wagner for the opportunity to include many new records and for his assistance in checking determinations of difficult specimens. During the preparation of the maps I have consulted the herbaria of the University of Michigan, Michigan State University, Wayne State University, Western Michigan University, the University of Notre Dame, the University of Illinois, the University of Wisconsin, the Field Museum of Natural History, and Albion College. I wish to thank the curators of these herbaria for the many courtesies extended to me. My own collections are deposited in the herbarium of Cranbrook Institute of Science. No keys are included since all of the species are described and illustrated in the most recent regional fern guide (Wherry, 1961).

#### ABUNDANCE AND ECOLOGY

For many of the flowering plants, especially the more common and showy species, there is fairly reliable information as to their abundance at various times since botanists began to record our local flora. But, except for *Botrychium virginianum*, few such observations are available for the Ophioglossaceae, for even today the general collector tends to overlook most members of this family because they are so inconspicuous and because many of their best habitats hold little attraction for the botanist looking for flowering plants. However, by comparing my observations

made in essentially virgin forests, in the Huron Mountains of Marquette County and the Porcupine Mountains in Ontonagon County, with observations in second-growth woods, old abandoned fields, and roadside excavations, I have reached the conclusion that the species of this family have undergone a population explosion since the original forests were lumbered. Much of this population growth appears to be fairly recent because the colonies occur on what was once farm land. Unfortunately, we have little information about how soon a species can become established. In southeastern Michigan many good grape fern fields are found on marginal lands now in public ownership as recreation or hunting areas. Although dates of acquisition can be obtained for these tracts it is difficult to obtain information on how long ago farming ceased there. An extensive population of *Botrychium matricariifolium* containing plants up to nine inches high was found in Kent County in an old field believed to have been out of cultivation less than thirty years. Hiltunen (1961) established a possible date for a roadside borrow pit in Chippewa County. *Botrychium multifidum*, *B. simplex*, and *Ophioglossum vulgatum* were well established there twenty-five years after the excavation was made.

At first glance the range of habitats for the family seems varied in the extreme, but analysis shows that all have one thing in common: some type of disturbance which opened the area to colonization. Many habitats show various stages of gradual revegetation after lumbering, cultivation, or roadbuilding. Some types of intermittent disturbance such as seasonal flooding seem to favor the development of colonies of the ferns by discouraging growth of competing vegetation. In virgin forests the habitats are subject to the flow of run-off water in ravines, to water level changes at the edge of swamps, lakes, or seasonal ponds, and to disturbance by travel along woodland trails. Wagner (1963b) has called attention to the effects of grazing by cattle, horses, and deer; and, in fact, *Ophioglossum* is not infrequently found at the edge of marshes in pasture fields. Among our best localities for grape ferns are fields and orchards reverting to bram-

bles, poison ivy, and small trees and shrubs. In second growth woods the ferns especially favor former trails and roadways.

Several species frequently share the same habitat, and discovery of one of the larger species can lead to the finding of others. An example is a Luce County locality where I chanced to notice some *Botrychium multifidum*, and when I bent over to look at them I then saw some small plants of *Ophioglossum*. Kneeling to examine the *Ophioglossum* I only then saw some tiny plants of *Botrychium simplex*. All four species of the evergreen grape ferns found in Michigan have been found in one old field on several occasions, sometimes with other members of the family as well.

#### ABNORMAL PLANTS

Most, if not all, of the species of *Botrychium* have a tendency to produce abnormal plants, with plural fertile spikes or with sporangia borne on parts of the normally sterile leaf tissue. These types of variation have been discussed in detail by Chrysler (1926). Some examples of these forms are preserved in the herbaria examined, including some showy specimens of *Botrychium dissectum* with double or triple fertile spikes, *B. dissectum* with entire pinnules on the lateral pinnae transformed to fertile parts, and numerous examples of the smaller grape ferns, especially *B. matricariifolium* and *B. simplex*, with sporangia on the tissue of the sterile segment. Three collections have been seen of large forms of *B. simplex* in which there were two additional fertile spikes produced at the bases of the lateral lobes of the sterile segment, giving the plants three fertile spikes in all. While names have been proposed for abnormal forms they represent the naming of aberrant individuals from otherwise normal populations, and I have chosen to ignore them in preparing the distribution maps.

#### BOTRYCHIUM

As now interpreted the genus *Botrychium* in Michigan includes ten species: four of the *Sceptridium* or Evergreen Grape Fern group (*B. dissectum*, *B. multifidum*, *B. oneidense*, and

*Botrychium dissectum* Spreng. f. *dissectum*



*Botrychium dissectum* f. *obliquum* (Muhl.) Fern.



*Botrychium multifidum* (Oenl.) Rupt.



*Botrychium oneidense* (Gilbert) House



MICHIGAN DISTRIBUTION OF *BOTRYCHIUM DISSECTUM* F. *DISSECTUM*, *B. DISSECTUM* F. *OBLIQUUM*, *B. MULTIFIDUM*, AND *B. ONEIDENSE*.

*B. ternatum*), five of the *Eubotrychium* group (*B. lanceolatum*, *B. lunaria*, *B. minganense*, *B. matricariifolium*, and *B. simplex*), and the common *B. virginianum* of the *Osmundopteris* group. *Botrychium boreale* was reported from the state in Beal's *Michigan Flora* (1904), but the specimen was a misidentified *B. matricariifolium*, and the species was not included by Billington.

BOTRYCHIUM DISSECTUM Spreng.

PLATE 16.

Most authors include both the highly dissected leaf form and the "obliquum" forms under this species, although Wherry (1961, pp. 230, 232) has maintained the two as separate species while noting that there is much intergradation between the two in the Great Lakes region. Since many botanists segregate their collections of the plants with dissected fronds from the others, I am including maps for each. As can be seen, in most counties there are records for both leaf forms. During our fieldwork we found that while the "obliquum" forms are the more prevalent, careful search of most populations will reveal some plants of the dissected form. While I have seen one or two plants of the dissected form growing alone I have never seen an extensive population in which it was not greatly outnumbered by the "obliquum" forms. In Southern Michigan this species, in a great variety of leaf forms, is a common plant of old fields and second-growth woods. Northward it becomes less frequent, and the Marquette County records, from the Huron Mountains, are the most northerly known in the Great Lakes region. Both leaf forms were found there.

BOTRYCHIUM MULTIFIDUM (Gmel.) Rupr.

PLATE 16

Although *Botrychium multifidum* and the variety *intermedium* were mapped separately in *Ferns of Michigan* such a separation now appears to be purely arbitrary. During our field investigations we have seen plants varying in size from those with little three-lobed fronds still attached to the gametophytes on up to plants with great, fleshy, sterile fronds as much as ten inches across. Although found throughout the state it is more common northward, and in the Upper Peninsula it is the only common

*Botrychium ternatum* (Thunb.) Sw.

*Botrychium lanceolatum* subsp. *angustisegmentum* Pease & Moore



*Botrychium lunaria* (L.) Sw.

*Botrychium matricariifolium* A. Br.



MICHIGAN DISTRIBUTION OF *BOTRYCHIUM TERNATUM*, *B. LANCEOLATUM* SUBSP. *ANGUSTISEGMENTUM*, *B. LUNARIA*, AND *B. MATRICARIIFOLIUM*.

member of the *Sceptridium* group.

BOTRYCHIUM ONEIDENSE (Gilbert) House PLATE 16

This species has been assigned to both of the preceding species as a variety, and records for it were included with *B. dissectum* in *Ferns of Michigan*. However, mature plants have a very distinctive look in the field, and it has now been shown to deserve species status. It is most frequent in the southern half of the Lower Peninsula where it seems to favor moist woodlands, although it is sometimes found in old fields.

BOTRYCHIUM TERNATUM (Thunb.) Swartz PLATE 17

For years all members of the *Sceptridium* group were assigned to this species under one or another varietal name. When they were then separated as species it was thought that *B. ternatum* in the true sense was confined to Japan and eastern Asia. American collections were referred to *B. multifidum*. However, Wagner (1959) pointed out that a fern that is apparently indistinguishable from the Japanese plant does occur here. He has outlined the characters which distinguish it from the other American species. The small, compact plants of *B. ternatum* that occur in some parts of the Great Lakes region were described as *B. multifidum* f. *dentatum* Tryon. In the living plants the tendency for the pinnae to be concave beneath is the most readily noticed character. As yet the distribution of this newly recognized species is poorly known. Most collections are from sandy soil; in the jack pine areas of the northern Lower Peninsula large colonies have been found around lakes and ponds where there has been a marked drop in water levels. As in the other members of the *Sceptridium* group, plants of open places tend to be small and compact whereas in moist woodlands the plants are larger and somewhat membranaceous.

BOTRYCHIUM LANCEOLATUM subsp. ANGUSTISEGMENTUM (Pease & Moore) Clausen. PLATE 17

Most of our records are from the western part of the Upper Peninsula. There it is most common in alluvial soil along stream courses in ravines and other moist woodland situations. By con-



*Botrychium minganense* Victorin



*Botrychium simplex* E. Hitchc.



*Botrychium virginianum* (L.) Sw.



*Ophioglossum vulgatum* var. *pseudopodium* (Blake) Farw.



MICHIGAN DISTRIBUTION OF *BOTRYCHIUM MINGANENSE*, *B. SIMPLEX*, *B. VIRGINIANUM*, AND *OPHIOGLOSSUM VULGATUM* VAR. *PSEUDOPODUM*.

trast the collections from Mecosta and Oakland counties in the southern Lower Peninsula are from old fields.

*BOTRYCHIUM LUNARIA* (L.) Swartz

PLATE 17

The Moonwort, a very elusive plant in those parts of the United States where it does occur, has been found mostly in the region near the Straits of Mackinac, where large areas in several counties have limestones and dolomites close to the surface. Some rather large colonies have been found in old fields there. The woodland form, f. *onondagense* (Underw.) Clute, is less common than the typical form.

*BOTRYCHIUM MATRICARIIFOLIUM* A. Braun

PLATE 17

Although known from only a few counties in 1952, this species has been found to be widely distributed throughout the state. It is extremely variable in size and leaf architecture, much of the variation apparently due to age. An interesting adaptation was noted in plants growing on the wooded lee slope of an active sand dune near Grand Marais, Alger County. In the larger plants, where the rhizome had been more deeply buried by the gradual buildup of sand on the slope, the buds for the next year had elongated as much as two inches so that in late August they were about the same distance below the surface as those of plants with more shallow rhizomes.

*BOTRYCHIUM MINGANENSE* Vict.

PLATE 18

Formerly treated as a variety or form of *B. lunaria* by most authors and included under that species in *Ferns of Michigan*, the Mingan Moonwort has been shown by Wagner and Lord (1956) to be a distinct species with twice as many chromosomes as *B. lunaria*. It has the same habitat requirements as that species and is found with it in many places in the limestone belt. The most unusual locality is that in Wayne County, in the southeastern Lower Peninsula, far to the south of all other stations. Although only one plant was found here originally (*Wagner 62093, MICH*), it was observed for several years, and now there are two. Further search may be productive here, for parts of Wayne and adjacent Monroe County are underlain by limestone.

## BOTRYCHIUM SIMPLEX Hitchcock

PLATE 18

The Little Grape Fern, despite its small size, is one of the most variable species in the genus. While various authorities have attempted to segregate forms or varieties based on the shape and insertion of the sterile blade, the field botanist who encounters a large population in Michigan frequently finds that plants corresponding to two or more of these variants could be selected from the assortment before him, but that the placement of many others would be difficult. Clausen (1938) lists four varieties, but at the same time points out that they tend to intergrade. Fernald (1949) refers to five recognizable variants, but then says of them, ". . . these too often seeming like responses to environment or to be stages of development."

Ecological factors appear to influence both the leaf form and time of appearance. As early as the middle of May *Botrychium simplex* has been collected in old fields, jack pine barrens, sandy borrow pits, and even on the shoulder of the highway, all situations which may be extremely dry later in the summer. These early plants mature and disappear rapidly. At a location in Berrien County where a number of plants were seen on a grassy hillside in May no trace of them could be found a month later. The prevalent form in these early colonies is var. *simplex*, with occasional plants approaching var. *compositum* (Lasch) Milde, but intermixed with them are slender plants with the sterile blade much reduced and inserted high.

Woodland plants appear somewhat later, my own collections being as late as the first week in September. Some of these late plants are rather lax and may even be decumbent under a carpet of leaf mold. A frequent habitat is along the highwater mark of seasonal ponds in low, sandy woodlands. Most of these plants might be referred to var. *laxifolium* Clausen or to var. *tenebrosum* (A. A. Eaton) Clausen, but plants with blades inserted low occur with them. An interesting variation in the late season plants has been found in six counties in the Upper Peninsula and northern Lower Peninsula, most stations being in humus in woods in the limestone belt. These plants have a very promi-

ment fertile segment with a thick, fleshy stalk and sterile blades variously inserted and frequently poorly developed.

In view of the great diversity within the various populations it has seemed advisable to include all of the variations on one map.

BOTRYCHIUM VIRGINIANUM (L.) Swartz

PLATE 18

The Rattlesnake Fern, the most common member of the family, and the best known because it shares the woodland habitat of many spring flowers, has now been collected in all except one of Michigan's counties, Gladwin, a county whose ferns were poorly represented in the herbaria examined. In the Upper Peninsula it is sometimes found in exposed habitats as well as in the woods. In roadside clearings and similar open places it is more compact in form and has a firmer texture, changes similar to those found in other Botrychiums in such surroundings. Although subsp. *europaeum* (Angstr.) Clausen has been attributed to the state, the Michigan specimens all seem to represent ecological variations.

#### OPHIOGLOSSUM

Only one member of the genus is known from Michigan, the Common Adder's-tongue. The report of the Limestone Adder's-tongue, *Ophioglossum engelmannii* Prantl, by Beal (1904) was based on a misidentified specimen.

OPHIOGLOSSUM VULGATUM var. PSEUDOPODUM (Blake) Farw.

PLATE 18

The Common Adder's-tongue is among the least known of our ferns although it probably occurs throughout the state. Usually the first plant in a locality is difficult to find due to the way this species blends with the grasses and other vegetation, but after the first one is noticed search may reveal scores or even hundreds more. One of the interesting habitats found was an interdunal meadow just back of the first row of dunes along Lake Michigan in Schoolcraft County where many plants in a large colony had two fronds from the same rootstock.

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### A Preliminary Review of Spore Number and Apogamy within the Genus *Cheilanthes*

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Interesting connections exist among spore number, apogamy, xerophytism, and hybridization. Wagner, Farrar, and Chen (1965) summarized, in a very clear fashion, our knowledge about spores and apogamy. We wish to paraphrase their summary and add other observations: apogamy, which is known in 80 species of ferns, involves no fertilization and new sporophytes grow out of the gametophytes as "buds." Since there is no fusion of gametes, the chromosome numbers of the gametophytes and sporophytes are the same. Usually only eight spore mother cells, instead of 16, are produced in each sporangium, and one division each of the mother cell and of the daughter cells finally produces 32 spores which are usually well-formed and viable. There is a doubling of the chromosomes in the spore mother cells prior to meiosis. After meiosis (reduction) each spore will thus have the same number of chromosomes as that of the sporophyte which produced it, and the spore will produce a gametophyte with the same number of chromosomes as the sporophyte. The presence, then, of 32 spores per sporangium is presumptive evidence that the species involved is apogamous. The most direct evidence of apogamy, of course, would be the observation that the gametophyte lacked archegonia (female sex organs).

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<sup>1</sup>It is a pleasure to acknowledge the aid of Miss Phyllis Frank and the financial support and encouragement of the National Science Foundation (Grant No. GB-4630) and the All-University Research Fund.